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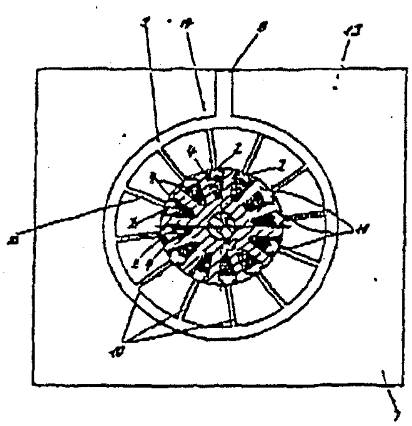
(54) Method for Sealing the Slots of an Armature, as well as Apparatus for Performance of the Method

The armature (1) of an electric machine provided with a winding is inserted radially into a mold (7) largely free of play, in which a gate (10) is provided at half-height of the armature lamination (12) for each slot (2) accommodating the winding wires. With the mold closed, an injectable insulation material is injected under high pressure at high velocity almost simultaneously into each slot (2) in the center relative to its longitudinal center axis until all the existing cavities in the mold are filled. After cooling of the injected material, the armature is released from the mold.



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Claims

1. Method for sealing the slots accommodating the winding wires of an armature for electric machines, especially commutator motors, characterized by the fact that the armature (1) is inserted largely free of play into a mold (7) that bounds the slots (2) in the longitudinal direction, that an injectable insulation material is injected under high pressure with high velocity into the slots (2) until the existing cavity in the mold is filled and that the armature is released from the mold after cooling of the insulation material.

2. Method according to Claim 1, characterized by the fact that the insulation material is simultaneously injected into each individual slot (2) roughly in the center relative to its longitudinal center axis.

3. Method according to Claim 1 or 2, characterized by the fact that the insulation material is injected within about 1 to 5 seconds.

4. Method according to one of the Claims 1 to 3, characterized by the fact that the insulation material is injected with a pressure of about 1.250 bar into slots (2).

5. Method according to one of the Claims 1 to 4, characterized by the fact that a thermoplastic, preferably a glass-fiber-reinforced thermoplastic, is used as insulation material.

6. Method according to one of the Claims 1 to 4, characterized by the fact that a thermosetting plastic, preferably glass-fiber-reinforced thermosetting plastic, is used as insulation material.

7. Method according to one of the Claims 1 to 6, characterized by the fact that during sealing of the slot (2), the winding heads (19) of armature (1) are molded around by insulation material emerging from the ends of the slots (2).

8. Method according to Claim 7, characterized by the fact that fan blades (16) are injected onto the molded-around winding heads (19).

9. Injection mold for performance of the method according to Claim 1, characterized by two mold halves each with a cylindrical recess corresponding to the diameter of the armature (1) being inserted and a face surface delimiting the slots (2) of armature (1), the parting plane (13) of mold (7) lying in the axial direction of the armature roughly at half-height of the armature lamination (12) with channel-like recesses arranged in each parting plane (13) that form gates (14) in the assembled mold (7), one gate (10) being allocated to each slot (2) over the periphery of armature (1).

10. Injection mold according to Claim 9, characterized by the fact that the gate (14) consists of an annular channel (9) supplied by an injection device arranged with radial spacing to armature (1), which is connected to radial channels (10) arranged in stellate fashion, whose discharges (11) each lie opposite a slot (2).

11. Injection mold according to Claim 10, characterized by the fact that the passage cross section of the annular channel (9) is greater than that of the radial channel (10).

12. Injection mold according to one of the Claims 9 to 11, characterized by the fact that the inside wall of mold (7) on its front end is preferably designed continuously tapered, starting roughly from the adjacent axial edges (15) of an inserted armature lamination (12).

13. Injection mold according to Claim 12, characterized by the fact that radial recesses, preferably designed with a rectangular cross section, are provided in the region of the tapering.

14. Injection mold according to Claim 13, characterized by the fact that the bottoms of the recesses extend at most up to an outer surface radially enclosing the armature (1) free of play.

15. Armature produced according to the method of Claim 1, characterized by the fact that the slots (2) are sealed by injected insulation material.

16. Armature according to Claim 15, characterized by the fact that the winding heads (19) of armature (1) have an enclosure (18) made of insulation material injected in one part with the slot closure.

17. Armature according to Claim 16, characterized by the fact that the injected enclosure (18) is formed tapered toward the faces of the armature (1).

18. Armature according to Claim 17, characterized by the fact that the enclosure (18) is tapered conically.

19. Armature according to Claim 17, characterized by the fact that the injected enclosure (18) is tapered in rounded-off fashion.

20. Armature according to one of the Claims 15 to 19, characterized by the fact that the enclosure (18) carries fan blade (16) molded on in one part.

21. Armature according to Claim 20, characterized by the fact that the fan blade (16) ends within an outer surface enclosing the armature (1) free of play.

22. Armature according to Claim 20 or 21, characterized by the fact that the fan blade (16) is arranged radially aligned to shaft (3).

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Method for Sealing the Slots of an Armature, as well as Apparatus for Performance of the Method

The invention concerns a method for sealing the slot of an armature accommodating the winding wires according the preamble of Claim 1, as well as an apparatus for performance of the method.

In armature production thus far, an armature lamination has been arranged on a shaft, onto which a collector ring is also mounted coaxially as commutator. The armature lamination has continuous slots arranged in the longitudinal direction that are distributed over the periphery with equal spacing. A slot insulation is introduced according to the known methods into the slot and the winding made of copper conductors then introduced, which are connected in known fashion to the bars of the collector ring. To seal the slot, slot wedges are inserted into the slots in the longitudinal direction and the winding heads lying on the slot ends then fed in to consolidate the armature winding; epoxy resin, for example, is dripped onto the winding head.

This type of armature production is very labor-intensive and time-consuming (about 10 minutes) so that an armature produced in this way is relatively expensive.

The underlying task of the invention is to provide a simple method for sealing the slot and consolidating the winding, as well as an apparatus for performance of the method.

The task is solved according to the invention by the characteristics in Claim 1.

The insulation material enters the slots in the center with high pressure and flows on both sides to the faces of the slots so that the copper wires on the inside are firmly forced against the slot base starting from the injection site, the pressure forces propagating bow-like toward the faces of the slot. In this manner the filling factor of a slot is significantly improved, since less air lies between the individual wires and more limited magnetic losses and less internal heating therefore occur. With the same design dimensions as in the prior art,

based on the method according to the invention, significantly higher powers can be achieved with an armature design, for example, as a rotor. At equal power as in the prior art, the design height could therefore be significantly reduced. Owing to the firm pressure, the copper wires lie absolutely firmly in the slots so that they cannot move relative to each other and wear of the enamel insulation of the winding wires during rough operation of the motor is avoided. Especially in rapidly running tracklaying vehicles, where accelerations of up to 9 g at frequencies between 25 and 100 Hz act on the winding wires, shorted coils due to broken enamel insulation are largely avoided.

In an advantageous modification of the invention, the winding heads of the armature lying outside of the slot are simultaneously enclosed by insulation material, i.e., completely molded around so that total encapsulation of the winding is achieved. Because of this, the winding wires are protected against damage from the exterior, like hot coal dust particles, and from harmful coal dust deposits between individual winding wires.

An advantageous apparatus for performance of the method, an injection mold, is mentioned in Claim 9. With such an injection mold, the method according to the invention in a simple layout can be carried out quickly and simply.

Additional features of the invention are apparent from the claims, the description and the drawings.

A practical example of the invention is shown in the drawings and further described below. In the drawings:

Figure 1 shows a top view of an armature whose slots are injected with insulation material,

Figure 2 shows a section along line II-II from Figure 1,

Figure 3 shows a section through an injection mold with the inserted armature.

The armature 1 depicted in Figures 1 and 2 consists of an armature lamination 12 of layered sheets insulated on one side, the armature lamination having several slots 2 distributed over the periphery in its longitudinal direction that serve to accommodate the windings of electrical conductors 4 that generate the alternating field. The conductors 4 are

formed from enameled copper wire, in which several conductors 4 are arranged in known fashion in the longitudinal direction of the lamination in a slot 2. Slot insulation 5 is introduced to the slot before insertion of the conductors 4 in order to avoid an electrically conducting connection to the lamination after wear of the enamel insulation. The winding heads 19 (only shown injected) of the conductors 4 lie outside of the armature sheets on the face of the lamination 12.

The slots 2 can naturally be formed with different slot cross sections.

In the present practical example, the armature 1 is designed as a rotor. The lamination 12 is arranged rotationally fixed on a shaft 3 that simultaneously carries a collector 6 as commutator unit on the ends of the slot 2 with a spacing from the lamination and winding head 19 and the collector is also rotationally fixed to shaft 3. The ends of the individual windings are connected in the usual manner to the bars of the collector.

An armature 1 assembled in this way is introduced to a mold 7, as shown in Figure 3 with the armature 1 inserted. The cylindrical internal space of mold 7 is adapted according to the diameter of armature 1 so that its outer surface lies against the inside wall of the mold 7 largely free of play.

The mold 7 consists essentially of two halves, whose parting plane 13 is provided in the longitudinal direction of the lamination at roughly half its height.

A gate 14 is provided in each parting plane 13 each with a half cross-section. In the assembled mold, the cross sections are congruent to each other so that a gate 14 with a corresponding passage cross section is formed.

In the present practical example, the gate 14 is formed from an annular channel 9 arranged with radial spacing from armature 1 from which radial channels 10 run in stellate fashion to the interior of mold 7, whose discharges 11 lie in front of a slot 2 of the armature 1 inserted in the internal space, almost precisely in its center in the longitudinal direction of the slot. The number of radial channels 10 therefore corresponds to the number of longitudinal slots 2 in armature 1.

The annular channel 9 is connected to a device (not further shown) that forces the employed injectable insulation material under high pressure and high velocity into the ends of annular channel 9 through radial channels 10 into the slots 2.

In order to obtain good material distribution with the most uniform possible filling of all slots, the annular channel 9 is designed larger in passage cross section than the radial channel 10.

The faces lying across the longitudinal direction of armature 1 of the molds 7 (not further shown) are preferably flat and have a central opening to accommodate the shaft 3 bearing the lamination and the collector 6 arranged on shaft 3. The inside wall of the mold tapers to the face of mold 7 facing the collector roughly to the outer periphery of the collector in conical fashion, starting roughly from the adjacent axial edge 15 of the lamination 12. The inside wall has a similar trend on the opposite face of mold 7. Preferably it tapers toward the shaft or toward the rectangular face of mold 7 relative to shaft 3. The tapering is curved, preferably circular.

The end taperings of mold 7 are provided so that the winding heads do not rest against the inside wall of the mold.

With the mold closed, injectable insulation material, preferably a thermoplastic, is forced into the annular channel 9 under high pressure via the connectors 8, from which the thermoplastic enters the slots 2 in the center at about 1200 bar through radial channels 10. This occurs at high speed so that, despite one connector 8, it is injected almost simultaneously in all slots 2. Because of the material shooting into the slot, the copper conductors 4 are forced against the slot base and pressed bow-like into the slot owing to the injected material flowing toward the open slot end. Because of this, a very high copper filling factor for the slot is achieved and almost no air is present between the individual winding wires. The injected material emerging from the ends of slots 2 fills the free space between the ends of molds 7 and fully encloses the winding head 19 of armature 1. This entire injection process occurs at a very high injection speed, in which the injection process is concluded in about 1 to 5 seconds. This prevents the enamel insulation of the copper

conductors 4 from melting and causing an electrical short circuit so that the power of the armature is significantly reduced and possibly the armature made unusable. The cooling time of the mold begins immediately after termination of injection and amounts to about 20 seconds. After this cooling time, the temperature of the injected material lies below the melting point of the enamel insulation of the copper conductors 4 and the thermoplastic has solidified to the point that mold release can occur.

The total operating time for such an armature 1 on the order of about 1000 watts amounts to about 40 to 50 seconds from insertion into the mold to removal from the mold.

It should be emphasized that the copper conductors 4 in the injection molding method according to the invention are not subjected to any tensile stresses in the slots, so that winding ends welded onto the collector are not torn off.

The copper filling factor for a slot can be improved with this method up to 25% so that smaller magnetic losses and less internal heating occur. Because of the higher filling factor, more power is attainable from the same lamination cross section of a motor armature than in the ordinary prior art. This means that, owing to the method according to the invention, smaller armatures and stator sheets can be used with the same power, so that design height can be reduced.

Owing to the copper conductors pressed tightly against each other in the slots, movement of these conductors relative to each other is not possible either so that the enamel insulation cannot be worn away. The hazard of a shorted coil, especially in rough operation, is significantly reduced, which is a particular advantage in rapidly operating tracklaying vehicles, where accelerations of 9 g with a frequency between 25-100 Hz occur.

The molded-around winding heads protect the copper wires from external damage from hot coal dust particles and from harmful coal dust deposits between the individual winding wires. The mechanical integrity of the individual wires relative to loosening because of centrifugal forces is also increased.

Recesses are advantageously provided in the region of the conical tapering of the mold that are aligned radially relative to shaft 3 and have an essentially rectangular cross section. Because of such recesses, fan blades 16 are molded on during molding of the armature so that better cooling of the armature during operation as a rotor is possible without additional expense. Increased air is supplied to the collector 6 by the fan blades 16, so that it is better cooled. The temperature distribution of such an armature is very favorable, so that this type of armature can be used with particular advantage in pressure-encapsulated motors.

The fan blades 16 are designed so that they lie within an outer surface enclosing the armature free of play. A thermosetting plastic can also be advantageously used as injection material.

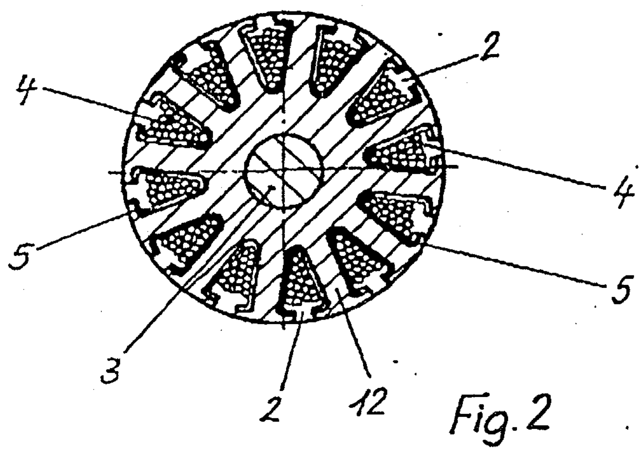

Fig. 2

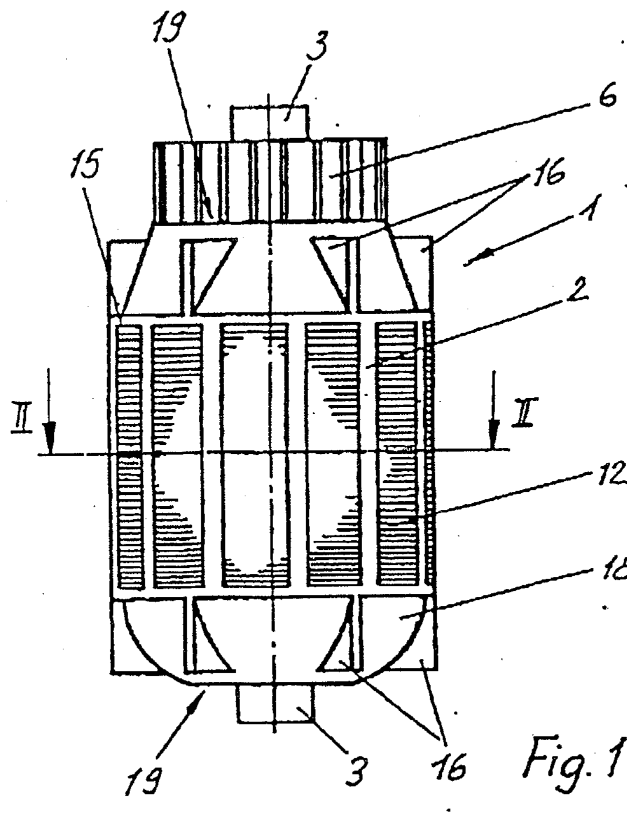

Fig. 1

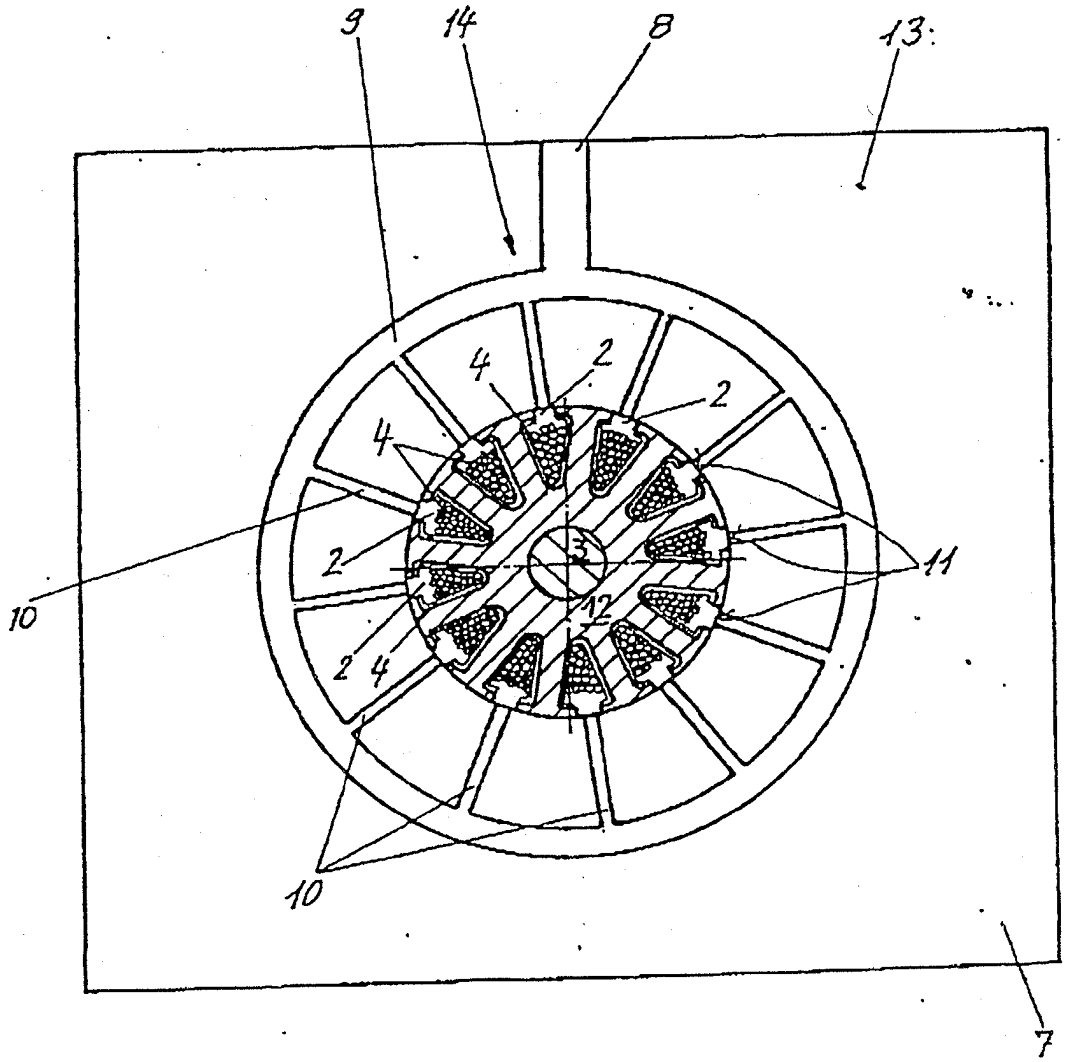

Fig. 3